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## Environmental Stewardship— Environmental Characterization and Remediation

### Standard Operating Procedure

# for **Monitoring Well and Borehole Abandonment**

☒ **NES Approved**

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**SOP-05.03,R3****Monitoring Well and Borehole Abandonment****Revision Log**

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# Monitoring Well and Borehole Abandonment

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## List of Acronyms and Abbreviations

API	American Petroleum Institute	NMED	New Mexico Environment
ATSM	American Society for Testing and Materials		Department
ECR	Environmental Characterization and Remediation	PPE	personal protective equipment
ER	Environmental Restoration Project	PL	project leader
ERS	Environmental Remediation and Surveillance	PVC	polyvinyl chloride
ENV	Environmental Stewardship Division	QPPL	Quality Program Project Leader
FTL	field team leader	QP	quality procedure
IWD	integrated work document	RCRA	Resource Conservation and Recovery Act
LANL	Los Alamos National Laboratory (or the Laboratory)	RPF	Records Processing Facility
		SOP	standard operating procedure
		SSHASP	Site-Specific Health and Safety Plan

# Monitoring Well and Borehole Abandonment

## 1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the process for monitoring well and borehole abandonment within the Environmental Stewardship (ENV) Division at the Los Alamos National Laboratory (Laboratory). Procedures described in this SOP are consistent with acceptable practice for monitoring well and borehole abandonment under Resource Conservation and Recovery Act (RCRA) and American Society for Testing and Materials (ASTM) guidance. This procedure integrates the criteria of the “Environmental Stewardship – Environmental Characterization and Remediation (ECR) Quality Management Plan,” hereinafter referred to as the Quality Management Plan (QMP).

## 2.0 SCOPE

This SOP is a mandatory document and shall be implemented within the ENV Division when conducting monitoring well and borehole abandonment.

## 3.0 TRAINING

- 3.1 **Participants** shall train (e.g., read and/or classroom) to and use the current version of this SOP; contact the author of this SOP if the text is unclear.
- 3.2 **Participants** using this SOP shall document training in accordance with QP-2.2, “Personnel Training Management,” using the training documentation link at the end of this document if they possess a CRYPTOCARD and administrative authority to the Laboratory, employee development system (EDS), or using the Training Documentation Form located in the forms section of the ENV-ECR web page.
- 3.3 The **Field Team Leader (FTL)** shall monitor the proper implementation of this procedure and ensure that relevant team members have completed all applicable training assignments in accordance with QP-2.2.
- 3.4 **Participants** may request any needed assistance with implementation of this procedure from the ECR Quality Integration and Improvement (QII) team.

## 4.0 DEFINITIONS

**Note:** Definitions specific to this procedure

- 4.1 **Abandonment**—The plugging or complete sealing of a well or borehole with materials of low hydraulic conductivity in such a manner as to preclude migration of surface runoff or ground water along the length of the well.

- 4.2 Annular seal—The material, usually cement grout or bentonite, placed in the space between the borehole wall and the well casing for zone isolation; especially used to prevent surface or shallow contamination from entering the well-screen interval.
- 4.3 Annular space or annulus—The space between the borehole wall and the well casing, or the space between a well casing pipe and a liner pipe.
- 4.4 Bentonite/Bentonite annular seal—A hydrous aluminum silicate (clay) in slurry, powder, granular, or pellet form that, when hydrated, provides an impervious seal between the well casing and the borehole wall. Bentonite may also be used in a 2% to 5% mixture by weight of bentonite powder with Portland Type I or II cement to form a pumpable grout seal that expands as the material hardens.
- 4.5 Filter pack—Sand, gravel, or glass or ceramic beads that are uniform, clean, and well rounded. Placement in the annulus of the well, between the borehole wall and the well screen, prevents foreign material from entering through the well screen and stabilizes the formation.
- 4.6 Grout—Cement or bentonite mixtures used in sealing boreholes and wells and for zone isolation. Only Portland Type I, Type II, or Type I/II cements are approved for use at investigative sites.
- 4.7 Monitoring well—Any well or borehole constructed for the purpose of monitoring fluctuations in groundwater levels, quality of groundwater, or the concentration of contaminants in the vadose zone or groundwater.
- 4.8 Site-Specific Health and Safety Plan (SSHASP)—A health and safety plan that is specific to a site or ER-related field activity that has been approved by an ER health and safety representative. This document contains information specific to the project, including the scope of work, relevant history, descriptions of hazards by activity associated with the project site(s), and techniques for exposure mitigation (e.g., personal protective equipment [PPE]) and hazard mitigation.
- 4.9 Tremie pipe—A small-diameter pipe used to carry sand pack, bentonite, or grouting materials to the bottom of the borehole. Materials are pumped under pressure or gravity-fed with clean water as transport agent to the borehole bottom through the pipe. The pipe is retracted as the annulus is filled.
- 4.10 Well casing—A solid piece of pipe, typically steel, stainless steel, or polyvinyl chloride (PVC), used to keep a well open in either unconsolidated materials or unstable rock. Well casing also serves to create zone isolation when combined with cement grout or bentonite in wells with multiple screened intervals.

- 4.11 Well screen—Perforated casing that allows fluids, but not solid material, to enter the well. The well screen minimizes or eliminates the movement of aquifer material into the well.

## 5.0 RESPONSIBLE PERSONNEL

The following identifies the personnel responsible for actions in this procedure:

- ENV Division personnel or participants (hereinafter referred to as “participants”)
- Field team leader
- Project leader

## 6.0 BACKGROUND AND PRECAUTIONS

- 6.1 Use this procedure in conjunction with an approved Site-Specific Health and Safety Plan (SSHASP).
- 6.2 This procedure must be implemented under an approved readiness review per QP-5.3, “Readiness Planning and Review Process.”
- 6.3 This SOP shall be used in conjunction with an approved Integrated Work Document (IWD). Also, consult the IWD for information on and use of all PPE.
- 6.4 A properly abandoned monitoring well or borehole ensures that no surface water or contamination threatens previously uncontaminated zones as a result of the well installation.
- 6.5 Refer to the site-specific documents for details of well or borehole construction at a given site.

## 7.0 EQUIPMENT

- 7.1 The responsible **project leader (PL)** shall prepare an equipment and supply checklist, if applicable, for use during implementation of this procedure.
- 7.2 **Participants** shall use only the equipment and supplies authorized by the responsible PL.
- 7.3 **Participants** shall report to the PL any equipment or supply item listed on the checklist that is not available for use and the need for equipment or supply items in addition to or different from the equipment and supplies listed on the checklist, if applicable.
- 7.4 The following equipment and supplies may be needed to properly execute the instructions in this SOP:
- Drill rig or wireline rig and accompanying equipment

- Casing perforator and/or cut-off tool
- Cement
- Tremie pipe
- Grout pump with mechanical mixing ability
- Bentonite (powder, pellets, or granular, depending on the specific need)
- Any additional supplies listed in associated procedures and equipment specified in associated SOPs and the SSHASP.

## 8.0 PROCEDURE

Make any deviations from this SOP in accordance with QP-5.7, “Notebook Documentation for Environmental Restoration Technical Activities” and/or SOP-01.01, “General Instructions for Field Investigations.”

**Note:** Subcontractors performing work under the ER Project’s quality program may follow this SOP for abandoning monitoring wells and boreholes. Subcontractors’ own procedures may be used, provided that the substitute procedures meet the same requirements for well and borehole abandonment and the requirements prescribed by the ECR QMP, and have been approved by the ECR Quality Program Project Leader (QPPL) before starting the activity or activities.

### 8.1 Monitoring Well Abandonment

General requirements for abandoning monitoring wells are listed below.

#### 8.1.1 Preliminary Work

- Well-abandonment operations may only occur with the approval of the appropriate PL. Review SOP-01.06, “Management of Environmental Restoration Project Waste,” to determine the requirements for proper disposal of all materials removed from a well as part of abandonment.
- The conditions and construction details of a monitoring well will be evaluated before it is plugged and abandoned. The well should be sounded (its depth measured with a weighted line or other appropriate method) immediately before it is plugged and abandoned to make sure that it contains no obstructions that could interfere with filling and sealing. In some cases, it may be appropriate to run video logging or other geophysics (e.g., gamma) to document downhole conditions.

#### 8.1.2 Sealing Conditions

The following minimum sealing conditions requirements shall be met:

- Where possible and practical, the monitoring well can be plugged and abandoned by removing all material within the original borehole, including the well casing, filter pack, and annular seal. Material in the borehole may be removed by means of overdrilling (with a hollow-stem auger). Review SOP-01.06 to determine the requirements for the disposal of removed materials. The hole can then be reamed and completely filled with grouting material or cuttings as specified in Section 8.5 of this procedure.
- In accordance with the New Mexico Environment Department (NMED) Order on Consent, sealing material should be pumped under pressure from the bottom of the hole (via the tremie pipe method) to ensure that the monitoring well is properly filled and sealed. Approval for deviations from this requirement must be obtained in writing from the NMED Hazardous Waste Bureau.
- If the casing, filter pack, and annular seal materials cannot or should not be removed, the materials may be left in place. The casing left in place should be perforated or punctured to allow proper placement of sealing materials. This sealing material should be pumped under pressure from the bottom of the hole (via the tremie pipe method) to ensure its proper distribution.
- Where the casing is left in the hole, the casing may be cut approximately 1-2 ft below the surface.
- The monitoring well should be filled to the surface with cement grout or within two feet of the surface with bentonite grout. After the placement of the bentonite grout (if used) the remaining portion of the well should then be sealed with a Portland Type I, II, or Type I/II cement with 2% to 5% bentonite as specified in Section 8.5 of this procedure.

## 8.2 Borehole Abandonment

General requirements for abandoning boreholes are listed below.

### 8.2.1 Preliminary Work

The borehole will be inspected immediately before filling and sealing operations. All obstructions that could interfere with filling and sealing operations will be removed before filling and sealing. All waste generated from borehole and well abandonment will be handled in accordance with SOP-01.06.



### 8.2.2 Sealing Conditions

Boreholes can be completely filled with grouting material and/or cuttings as specified in Section 8.5 from bottom to top of the borehole.

## 8.3 Placement of Material

### 8.3.1 Placement Method

In accordance with the NMED Order on Consent, sealing material should be pumped under pressure from the bottom of the hole (via the tremie pipe method) to ensure that the monitoring well is properly filled and sealed. Approval for deviations from this requirement must be obtained in writing from the NMED Hazardous Waste Bureau.

### 8.3.2 Timing of Placement

Place the sealing material in one continuous operation (or “pour”) from the bottom to the top of the well or boring, unless conditions in the well or boring dictate that sealing operations be conducted in a staged manner.

### 8.3.3 Groundwater Flow

If subsurface pressure produces a flow of groundwater into a well or boring that is significant, use special care to restrict the flow while placing sealing and fill material.

### 8.3.4 Verification

Verify that the volume of sealing and fill material placed during abandonment operations equals or exceeds the volume to be filled and sealed. This is to help determine whether the well or boring has been properly plugged and abandoned and that no jamming or bridging of the fill or sealing material has occurred.

## 8.4 Options

### 8.4.1 Monitoring Wells and Boreholes in Urban Areas and Active Technical Areas.

8.4.1.1 The following options may be necessary to exercise for plugging and abandoning monitoring wells and boreholes in urban areas and within portions of technical areas, depending on potential future site use. Implementation of these options requires written approval by the NMED Hazardous Waste Bureau.

- The upper surface of the sealing material needs to end at a depth of 5 ft below ground surface if excavation is possible at that location in the future.
- If the well casing was not extracted during abandonment and sealing operations, a hole can be excavated around the well casing to a depth of 5 ft below ground surface after sealing operations have been completed and the sealing material has adequately set and cured.
- The exposed well casing may then be removed by cutting the casing at the bottom of the excavation.
- The excavation will be back-filled and compacted with clean, native soil or other suitable material.

#### 8.4.1.2 Temporary Cover

- Whenever work is interrupted by such events as overnight shutdown, inclement weather, or other delays, the monitoring well or borehole opening and any associated excavations should be covered at the surface. This is to ensure public safety and to prevent the entry of foreign material, water, or contaminants. The cover should be held in place or weighted down in such a manner that it cannot be easily removed, except by equipment or tools.

### 8.5 Sealing Material

Sealing material used for abandoning monitoring wells or boreholes of a depth greater than 200 ft shall consist of neat cement, with a 2%- to 5%-by-weight bentonite mixture, or high-solids bentonite grout to within two feet of ground surface. The remaining portion of the well should then be sealed with a Portland Type I, II, or Type I/II cement with 2%- to 5%-by-weight bentonite as specified above.

#### 8.5.1 Water

Water used to prepare sealing mixtures should generally be of potable-water quality and shall be compatible with the type of sealing material used. It also should be free of petroleum and petroleum products and free of suspended matter. The quality of water to be used for sealing mixtures will be determined where unknown and the water source will be pre-approved by the PL and documented in the daily log.

#### 8.5.2 Cement

Cement used in sealing mixtures shall meet the requirements of American Society for Testing and Materials (ASTM) C150-92, Standard Specification for Portland Cement, including the latest revisions thereof.

8.5.2.1 Types of Portland cement available under ASTM C150-92 for general construction are listed below.

- Type I—General purpose. Similar to American Petroleum Institute (API) Class A.
- Type II—Moderate resistance to sulfate. Lower heat of hydration than Type I. This is similar to API Class B.
- Type I/II—General purpose, mixture of Types I and II. Cement grout used for borehole sealing and hole abandonment will have a mixture of 2% to 5% bentonite powder added and be thoroughly mixed before pumping.
- Neat Cement—For Types I and II Portland cement, neat cement will be mixed at a ratio of one 94-lb sack of Portland cement to five to eight gallons of clean water.

8.5.2.2 Concrete shall be used for the surface pad only.

8.5.2.3 Cement-based sealing materials should be mixed thoroughly by machine to provide uniformity and to ensure that no lumps exist before pumping. In some cases, the grout may be mixed by hand.

8.5.2.4 Ratios of the bentonite used with cement-based sealing materials can be varied from 2% to 5% by weight. Variations will be approved by the PL. The bentonite will be dry-mixed before hydration, and additional water may be required.

8.5.2.5 Curing accelerators may be used for temporary and short-term surface casing seals. Typical accelerators are calcium chloride, sodium chloride, aluminum powder, or gypsum. The use of these materials requires approval by the PL or designee.

### 8.5.3 Bentonite

8.5.3.1 Bentonite clay in gel or slurry form has some of the advantages of cement-based sealing material. A disadvantage is that the clay can sometimes separate from the clay-water mixture. Although many types of

clay mixtures are available, none has sealing properties comparable to bentonite clay. Bentonite expands significantly in volume when hydrated. Only pure montmorillonite is an acceptable clay for bentonite annular seals.

- 8.5.3.2 Do not use bentonite clay seals where structural strength of the seal is required or where it will dry. Bentonite seals may have a tendency to dry, shrink, and crack where subsurface moisture levels are low. Bentonite clay seals can be adversely affected by subsurface chemical conditions, as can cement-based materials.
- 8.5.3.3 Do not use bentonite clay as a sealing material if roots from trees and other deep-rooted plants might invade and disrupt the seal and/or damage the well casing. Roots can grow into a bentonite seal in some surrounding soil and vegetation conditions.
- 8.5.3.4 Do not use bentonite-based sealing material, unless otherwise approved by the PL or designee, for sealing intervals of fractured rock or sealing intervals of highly unstable, unconsolidated material that could collapse and displace the sealing material. Bentonite clay should not be used as a sealing material where flowing water might erode it.
- 8.5.3.5 Specifically prepare bentonite clay products used for sealing material. (Consult the manufacturer's specifications for product[s] selected.) Used drilling mud cannot be used for sealing purposes.
- 8.5.3.6 Use only commercially prepared, powdered, granulated, pelletized, or chipped/crushed bentonite comprised of sodium montmorillonite for annular seals. The largest dimension of pellets or chips will be less than 1/5 the radial thickness of the annular space into which they are placed.
- 8.5.3.7 Thoroughly mix bentonite slurry mixtures with clean water before placement. Add a sufficient amount of water to bentonite to allow proper hydration (consult the manufacturer's specifications.) Water added to the bentonite for hydration will be of suitable quality, free of pollutants and contaminants, and pre-approved.

- 8.5.3.8 Bentonite slurry preparations normally require between 30 min and 1 h to adequately hydrate. Actual hydration time is a function of site conditions and the form of bentonite used. Finely divided forms of bentonite generally require less time for hydration, if properly mixed.
- 8.5.3.9 Dry bentonite pellets or chips may be placed directly into the annular space below water, where a short section of annular space is to be sealed. Care will be taken to prevent bridging during the placement of bentonite-seal material.

## 8.6 Reporting Requirements

Record all fieldwork and comments on the Monitoring Well and Borehole Abandonment Information form (Attachment A). At a minimum, record the depth from the surface to the bottom of the borehole, grout and bentonite/cuttings depth and location, ground surface construction details, and actual composition of the grout and backfill. Attach original “as completed” drawings and/or Borehole/Well Completion Information form (from SOP-05.01).

## 9.0 LESSONS LEARNED

- 9.1 Before performing work described in this QP, **participants** should go to the Department of Energy Lessons Learned Information Services home page, located at <http://www.tis.eh.doe.gov/II/II.html>, and/or to the LANL Lessons Learned Resources web page, located at [http://www.lanl.gov/projects/lessons\\_learned/](http://www.lanl.gov/projects/lessons_learned/), and search for applicable lessons.
- 9.2 During work performance and/or after the completion of work activities, **participants**, as appropriate, shall identify, document, and submit lessons learned in accordance with the LANL, Lessons Learned System located at [http://www.lanl.gov/projects/lessons\\_learned/](http://www.lanl.gov/projects/lessons_learned/).

## 10.0 RECORDS

The **FTL** is responsible for submitting the following records (processed in accordance with QP-4.4, Record Transmittal to the Records Processing Facility) to the Records Processing Facility:

- Monitoring Well and Borehole Abandonment Information form
- Field Log Books
- Daily Activity Logs (if used)

## 11.0 REFERENCES

To properly implement this procedure, **participants** should become familiar with the contents of the following ECR documents, available at [http://erinternal.lanl.gov/home\\_links/Library\\_proc.shtml](http://erinternal.lanl.gov/home_links/Library_proc.shtml):

- “Quality Management Plan”
- QP-2.2, “Personnel Training Management Process”
- QP-4.4, “Record Transmittal to the Records Processing Facility”
- QP-5.3, “Readiness Planning and Review Process”
- QP-5.7, “Notebook Documentation for Environmental Restoration Technical Activities”
- SOP-01.01, “General Instructions for Field Investigations”
- SOP-01.04, “Sample Control and Field Documentation”
- SOP-01.06, “Management of Environmental Restoration Project Waste”
- SOP-01.08, “Field Decontamination of Drilling and Sampling Equipment”
- SOP-05.01, “Well Construction”

## 12.0 ATTACHMENTS

**ENV Participants** may locate all example forms associated with this procedure at <http://erinternal.lanl.gov/Quality/user/forms.asp>. ENV participants may use documentation formats different from those attached in this SOP—provided that the substitute forms provide the information required in the official forms

Attachment A: Monitoring Well and Borehole Abandonment Information Form

[Using a “CRYPTOCARD,” click here to record "self-study" training to this procedure.](#)

If you do not possess a “CRYPTOCARD” or encounter problems, contact the ENV-ECR training specialist.

### Monitoring Well and Borehole Abandonment Information

Date/Time \_\_\_\_\_

Sheet \_\_\_\_\_ of \_\_\_\_\_

Technical Area \_\_\_\_\_ Focus Area (if applicable, or other location details) \_\_\_\_\_  
\_\_\_\_\_

Borehole ID: \_\_\_\_\_ Well Type (monitoring, etc.): \_\_\_\_\_

Site Work Plan \_\_\_\_\_

Grout Depth/Location:

Bentonite Depth/Location:

Other Fill Material Depth/Location:

Surface Construction:

Grout/Backfill Composition:

Additional Comments/Details:

*SOP-05.03*

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